

REMARKS/ARGUMENTS

Claims 1, 3-6, 8-10, 12-24, 26-29, 67 and 69 were rejected under Section 102 as being anticipated by Garg et al. As explained further below, one key distinction is that the present claims are directed towards tungsten carbide **alloyed with** fluorine in amounts ranging from 0.0005 to 0.5wt%.

Alloying of metals is a complex phenomenon of significant practical interest. For example, alloying of iron with various amounts of carbon under various conditions might change the mechanical and physical properties dramatically between mild iron, low carbon steel, high carbon steel and pig iron. The properties of steel, in particular its hardness, depend significantly on the carbon content and the form in which carbon is present in steel (e.g. as free cementite Fe_3C or alternatively as an interstitial solid solution of carbon in iron).

Alloying is to be distinguished from simple inclusions or the like. For example, free carbon inclusions in iron generally have a negative effect on its mechanical properties.

Garg et al. (and also the other references cited by the Examiner) makes no reference to the **alloying** of fluorine with tungsten carbide. Moreover, Garg et al. does not even mention incidental inclusion of fluorine in tungsten carbide. The Examiner has too broadly interpreted the prior art by arguing that the presence of gaseous tungsten hexafluoride inherently results in the inclusion of fluorine in the tungsten carbide layer. Indeed, in Garg, as in other conventional CVD techniques for depositing tungsten carbide layers, the fluorine component reacts with gaseous hydrogen to form hydrofluoric acid (HF), and is not incorporated in the tungsten carbide layer. In particular, under stoichiometric conditions, fluorine from tungsten hexafluoride actively reacts with hydrogen forming volatile HF which is evacuated from the CVD reactor with the gas flow. It can be seen that Garg provides gaseous hydrogen significantly **in excess** of the required stoichiometric amount (1500 to 3000 SCCM), which in fact promotes removal of fluorine from the system in the form of volatile HF. This is in sharp contrast to the present invention, where it is desired to **alloy** fluorine in the coating rather than to remove it all from the system.

There is no disclosure in Garg relating to the inclusion, let alone alloying, of fluorine or of the effect that this may have on the properties of a tungsten carbide layer.

Since there is no teaching in Garg of a tungsten carbide layer alloyed with fluorine in the specific amounts claimed in claim 1 of the present application, there can be no anticipation of the claim.

With regard to obviousness, after extensive experimentation and analysis, the inventors in respect of the present application have found that **alloying** of tungsten carbide with various predetermined amounts of fluorine can significantly change the properties of the tungsten carbide material.

Too low an amount of fluorine (i.e. less than 0.0005wt%) has little or no effect on the physical properties of tungsten carbide.

On the other hand, too high an amount of fluorine (i.e. above 0.5wt%) causes high stresses and can result in cracking of the tungsten carbide layer.

The present inventors have found that, under certain conditions, fluorine can be **alloyed** into the crystalline lattice of tungsten carbide in such a way that the chemical bonds between fluorine, tungsten and carbon strengthen the material structure. One of the results of this alloying is a significantly higher hardness of the alloyed tungsten carbide, typically 30-40% higher than the hardness of the non-alloyed material.

The hardness of the tungsten carbide layers produced by Garg et.al was 2190 kg/mm², 2276 kg/mm², maximum 3060 kg/mm² (see Tables 2 and 3). By contrast, the maximum hardness obtained by way of embodiments of the present invention (see examples 8 and 9) was 3400 kg/mm² and 3500 kg/mm².

Alloying with fluorine as claimed in the present application also enhances material toughness and resistance to cracking, which are of significant benefit.

Claims 1, 2, 25, and 30 were rejected under Section 102 as being anticipated by Sumitomo Electric. Claims 1, 4-6, 12-14, 18-19, 27, and 28 were rejected under Section 102 as being anticipated by Tokunaga et al.

The arguments above with respect to the Garg reference apply also in relation to Sumitomo Electric (maximum hardness 2400 kg/mm²) and Tokunaga (no mention of hardness).

Furthermore, Tokunaga repeatedly refers to the use of X-ray diffraction analysis to demonstrate that the layers are **pure** tungsten carbide – in other words, no fluorine can be alloyed with the tungsten carbide.

As a further point, following the Examiner's line of reasoning, it would appear that the tungsten carbide coatings of the prior art of record should inherently contain traces of hydrogen, argon, tungsten and possibly components of the hydrocarbons propane, dimethylether or benzene, since these are also present in the reaction system as well as fluorine. Applicant respectfully disagrees with this reasoning, for the same reason that it is incorrect to assume that fluorine will inherently be alloyed in the prior art tungsten carbide coatings.

With respect to independent claim 13, an additional distinguishing feature of the present invention is that thermal pretreatment of the gaseous hydrocarbons is used in the chemical vapor deposition process. As explained in the description of the invention, the thermal pretreatment of the hydrocarbons forms active carbon containing radicals which interact with fluorine, both in the gaseous phase and on the surface of the coating. This results in chemical bonding of fluorine in the tungsten carbide layer, has a significant effect on the alloying of tungsten carbide with fluorine, and provides effective additional control over the coating properties. This pretreatment is important for achieving the alloying with fluorine in an optimal form. None of the references of record remotely disclose thermal pretreatment of gaseous hydrocarbons as claimed.

For claim 6, the material as claimed further includes fluorocarbon compositions. Accordingly, simultaneous alloying of the tungsten carbide coating with both fluorine and fluorocarbons is an additional result of the hydrocarbon gas pretreatment, and is not disclosed in any of the references of record.

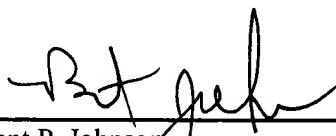
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For claim 14, this claim further recites that the carbon containing gas is propane. None of the references of record disclose this feature. In Garg, it discloses dimethylether. Tokunaga uses trimethylamine or other aromatic hydrocarbons such as benzene. Sumitomo uses benzene.

Applicant has made a sincere effort to place this application in a condition for allowance; therefore, such favorable action is earnestly solicited. In the event that a telephone conversation would further prosecution and/or expedite allowance, the Examiner is invited to contact the undersigned.

Respectfully submitted,

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